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COMPUTER-MANAGED INSTRUCTION IN THE NAVY: III. AUTOMATED PERFORMANCE TESTING IN THE RADIOMAN "A" SCHOOL

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Automated performance testing (APT) procedures were compared with manual testing procedures during computer-managed instruction (CMI) at the Radioman "A" school to determine if APT shortened teletyping training time. The effects of computer-generated Error Distribution Reports (EDRs) on performance progress were also studied. Results showed that APT speeded testing and scoring and shortened training time. Daily receipt of EDRs shortened the typing portion of the course by 3 days.

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FOREWORD

This research and development was performed under Work Unit Z1176-PN.01 (Improving the Navy's Computer-Managed Training System), as part of a project to improve the Navy's operational computer-managed instruction (CMI) system. It was sponsored by the Deputy Chief of Naval Operations (OP-01).

This is the third in a series of reports on Navy CMI. The first, NPRDC SR 80-33, described the CMI system and the development of the R&D project itself. The second, NPRDC TR 81-6, described the effects of alternative student-to-instructor ratios in CMI learning centers on student performance and instructor behavior. The purpose of the work described herein was to determine how the automated scoring of teletypewriting tests would affect training. Results will be used by the Chief of Naval Education and Training (CNET), the Chief of Naval Technical Training (CNTT), commanding officers of all the Navy CMI schools, and others concerned with computer-based instruction.

Appreciation is expressed to personnel at the Radioman "A" School at the Naval Training Center, San Diego, and to the staff at the Instructional Program Development Center, San Diego, for developing the automated teletyping testing; to the Management Information and Instructional Systems Activity, Memphis, for its computer support; and to the CMI System Manager, CNTT, for his support in managing the many operational elements of this R&D task.

JAMES F. KELLY, JR.
Commanding Officer

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Technical Director

SUMMARY

Problem and Background

A goal of the Navy's computer-managed instruction (CMI) system is to train students to meet specific performance objectives in the shortest possible time. Although testing of a student's knowledge has been automated, most performance skills are still manually tested and scored. With these manual procedures, testing sessions are lengthy, scoring is inaccurate, and no records of errors are kept. This lack of detailed information on past performance error hampers remediation efforts, and prolongs training time.

A system for automated performance testing (APT) has been implemented in the teletypewriter portion of the Radioman "A" School, San Diego. This system includes a computer-generated Error Distribution Report (EDR) that provides detailed feedback on student typing errors.

Objectives

The objectives of this effort were:

1. To determine whether test-related activities take less time under APT than under manual testing conditions.

2. To determine whether training time can be reduced by different applications of EDR use, and, if so, the most feasible and effective techniques for distributing EDRs to students and instructors.

Approach

Two experiments were conducted to investigate the influence of APT and EDR on the TTY portion of the Radioman "A" School training program. In the first experiment, the times required to perform test-related activities under manual scoring were compared with those required to perform such activities under automated conditions. In the second experiment, students in one group received EDRs daily; and those in another group, only during their second remedial session. Those in the third group received no reports. The numbers of hours, tests, and sessions required to reach specific performance levels were measured. Also, student attitudes toward CMI, APT, and EDRs were obtained through a random survey.

Results

1. Testing under the APT procedures was faster than manual testing and grading.

2. Students in the group receiving EDRs daily finished the typing portion of the course nearly 3 days faster than did students who did not receive the reports.

3. The attrition rate for the group receiving EDRs daily was 15 percent, compared to 35 percent for the group receiving no EDRs.

4. A majority of students favored the CMI system in general, and the APT program in particular. Students unanimously approved the use of EDRs.

Conclusions

It appears that APT is effective in reducing absolute test-taking time, and that EDRs could reduce both overall training time and attrition.

Recommendations

1. The RM school should continue to use APT and the EDRs on a daily basis.

2. The Chief of Naval Technical Training and the Service School Commands should apply APT procedures to similar typing tests at other Navy technical training schools with reasonable assurance of improved training cost effectiveness.

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INTRODUCTION

Problem

The Navy has attempted to meet the problem of rising technical training costs through the development of the computer-managed (CMI) system. This system manages self-paced, individualized instruction conducted at technical training schools across the continental United States through a centralized computer located at the Management Information and Instructional Systems Activity (MIISA), Millington, TN. Although this innovation in large-scale training has resulted in considerable reductions in training time, further modifications are desirable to achieve more cost-effective training. Therefore, the Navy Personnnel Research and Development Center (NAVPERSRANDCEN), San Diego, has established a comprehensive research and development (R&D) effort directed at making the CMI system an even more efficient component of Navy technical training. The initial report on this research effort (Van Matre, 1980) described the problem areas that limit the effectiveness of the CMI system and plans for R&D projects that will address these problem areas. The second report (Van Matre, Hamovitch, Lockhart, & Squire, 1981) described the effects of alternate student to instructor ratios on student performance and instructor behavior.

One R&D project that was described in the initial report concerned the development of automated performance testing (APT) and its implementation into the CMI system. The initial effort under this project involves the automation of teletypewriter (TTY) performance testing at the Radioman "A" school, San Diego. The instruction course conducted at the RM school was developed by the Instructional Program Development Center (IPDC). The computer program that automatically times and scores the TTY tests was developed by MIISA. NAVPERSRANDCEN developed the diagnostic typing report described by this research.

Background

The RM CMI Course

The course of instruction for the RM school consists of approximately 5 weeks of individualized instruction in common-core knowledge and TTY training, followed by a practical deck-watch phase, oriented toward either sea or shore duty, lasting 2 to 3 weeks. The common-core phase includes training in the use of basic Navy message forms and message handling procedures, and is conducted in conjunction with daily TTY training periods. In the deck-watch phase, the student demonstrates typing, message-handling, and equipment-operating skills in simulated on-the-job (sea or shore) situations, and is required to successfully complete a series of message-handling and equipment-operating routines.

Actual completion times for the course vary with individual students, since training is self-paced, and aptitudes and skills differ. However, management of the two phases of training--common-core knowledge and TTY training--is structured so that students complete the two phases at about the same time.

TTY Training and Testing in the CMI Course

To graduate from RM school, students must learn teletyping up to a minimum performance level of 700 functions (keystrokes) in a 5-minute period, with no more than five keystroke errors. This criterion level is equivalent to 28 words per minute of conventional typing. The typical student has had no previous typing instruction.

Basic typing instruction takes place in a small room for students at TTY terminals supported by videotape consoles. The students are given up to eight 2-hour sessions to learn the keyboard and build their typing speed up to 300 functions per 5-minute period (about 12 words per minute). Any time students feel that they are ready to qualify at a particular level of performance, they may request a test assignment from the computer. However, during the ninth session, if they have not already done so, students must attempt to qualify at the 300 function level. An additional requirement at this point is that certain critical lines must be typed with 100 percent accuracy. An error in one of these lines causes a "fatal error," and results in a 0 qualification level, or a "failed" test.

If students fail the 300 level test three times, they are assigned to mandatory night study, allowed one more practice session, and then assigned up to three more tests during the next session. Regardless of the outcome of these tests, the next three typing assignments serve as practice for the 400 function level. During the fourth session, students are instructed to qualify at 400 functions, and the same pattern of testing ensues as for 300 functions. A slight change in procedure occurs if a student fails the first three tests at the 500 function level. Because this level of skill is required to progress to other parts of the course, a student must remain in the typing session until he achieves the 500 function level. This can take more than 2 weeks of day-long typing, with mandatory night study after three test failures. If progress remains inadequate, the student ultimately goes before an academic review board. The procedure for qualifying at 600 functions is the same as for 300 and 400 functions; and that for qualifying at 700 functions, the same as for 500 functions. However, two extra practice sessions are allowed before the CMI computer requires a student to qualify at the final level of 700 functions.[1]

Manual Testing Procedures. A number of steps were specific to the manual testing procedures. Students first filled out administrative forms--social security number, name, course, and CMI item number. The computer assigned each student three tests that were taken at one of five testing sessions during the day. Usually, one of these sessions fell during the student's 2-hour TTY assignment. For the first test, the students typed for 5 minutes and noted the number of functions typed. This process was repeated for the second and third tests, after which students counted their errors on all three tests. Next, the students waited in line for the instructor to grade the tests and to fill out administrative computer forms to tell the CMI system whether the student had qualified. Students then waited in line to feed the administrative forms through the optical mark reader, and waited again for the terminet to print out their next assignment.

Automated Testing Procedures. After APT had been implemented, in July 1978, testing was conducted in a room with 86 TTYs, 30 of which were connected to a computer. The students practiced at one of the unconnected machines until they were ready to take the test. They then obtained a hard copy of the CMI-assigned test and signed on at one of the computer terminals by entering the same information required on the administrative forms under the manual system. The test began when the first function was struck, and the keyboard locked exactly 5 minutes later. A local computer scored the test and passed the results on to the CMI system. Test results and the student's next assignment were displayed at the student's terminal. The immediate feedback contained such information as the number of errors, the lines in which the errors occurred, the number of functions typed before the sixth error or before a fatal error, and the level of qualification. (Copy for an entire testing session is shown in Figure 1.) If a

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[1]Curriculum revisions implemented after the R&D covered in this report have altered specific qualifying procedures, although the same final qualification standard of 700 functions applies.

```
T I M E S  STARTED      0829781412
ENTER YOUR LAST NAME                        HAMO

NOW ENTER YOUR S-S-N  IE 999-99-9999     563-74-5708

NOW ENTER YOUR COURSE NUMBER -3- DIGITS 040

NOW ENTER YOUR ITEM NUMBER -6- DIGITS   041704

NOW ENTER YOUR TEST NUMBER -2- DIGITS 0 040

TEST NUMBER INVALID -- REENTER  . 12

YOU ENTERED THE FOLLOWING - - - -
NAME:      HAMO
SSN:       563745708
COURSE:    040
ITEM:      041704
TEST:      12
IF CORRECT TYPE -YES- IF NOT -NO-      Y

YOUR TIME BEGINS WHEN YOU KEY THE FIRST FUNCTION


NSS DE NBRG 031/27
PTTCZYUW RUHHLHN0457 3322300-CCCC--RUWJBGF RUECORR RUWJIAA RUWNDUA.
ZNY CCCCC
P 272300Z NOV 75
FM COMNAVBASE PEARL HARBOR HI
TO RUWJBGF/USS KING
RUECORR/USS BAUSELL
INFO RUWJIAA/COMDESRON FIFTEEN
RUWNDUA/COMCRUDESPAC SAN DIEGO CA
BT
C O N F I D E N T I A L DRILL //N01462//
DEPLOYMENT OF OPERATING FORCES (U)
A. COMCRUDESPAC LTR 1500.1A.
1. (C).SVCS ARRANGED TO ACCOMMODATE KING AND BAUSELL FOR UPKEEP.
2. (C) CRAIG PRESENTLY SKED FOR FUEL SERVICES ON 20 DEC.
ADS UPON ARR SUBIC
BT
./0457


NNNN
OLTC DE NEEX 024/25
PTTCZYUW RUWJEEN0245 3321456-CCCC--RUHHLHA RUWNDUA RUWJAJA.
ZNY CCCCC


TEST OVER, PLEASE WAIT


STUDENT NAME  HAMO                     SSN  563745703
 ITEM /  041704  TEST /  12      COURSE /040
YOU HAVE TYPED   598 FUNCTIONS WHICH QUALIFIES YOU
AT THE   500 FUNCTION LEVEL
YOU MADE THE FOLLOWING ERRORS:
MSG FORMAT /     ERRORS DESCRIPTION
 1  12 LINE 03     1    SUBSTITUTION
 X  XX LINE XX     2    GARBAGE LINE
 X  XX LINE XX     2    FATAL GARBAGE LINE
 X  XX LINE XX     2    FATAL GARBAGE LINE
 X  XX LINE XX     2    FATAL GARBAGE LINE
 X  XX LINE XX     2    FATAL GARBAGE LINE
ADDITIONAL LINES WITH ERRORS NOT DETAILED
TOTAL KEY FUNCTIONS TYPED  599
ESCESSIVE ERRORS, GRADING TERMINATED PREMATURELY.

YOUR NEXT ASSIGNMENT WILL BE PRINTED AT YOUR
LEARNING CENTER CLUSTER.  TEAR OFF THIS SUMMARY
STATEMENT AND REPORT TO YOUR LEARNING
SUPERVISOR.                 103145
```

Figure 1. Complete APT testing session

student failed the first test, the CMI system immediately assigned up to two more tests. Tests were assigned, timed, scored, and recorded quickly and accurately without instructor intervention.

The Error Distribution Report

One drawback of the original APT system was that it had few provisions for helping students identify their errors. The scoring program did not generate feedback on what specific errors the student had made. Without knowing these specific errors, students could not correct them as efficiently as when all errors were identified. To correct this deficiency, NAVPERSRANDCEN designed a computer-operated error distribution report (EDR) that provided detailed feedback on student typing errors.

Prior to development of the EDR, remedial procedures were conducted along traditional lines. During remedial night study, an instructor observed a student typing certain diagnostic passages for 30 minutes, and then checked the typing to identify particular problem areas. However, he had only that one sample of typing on which to base the proper remedial assignments. The EDR was designed to automate and increase the efficiency of this function, as well as to make greater use of the computer scoring program.

EDRs are printed on one page for each student, and the display consists of two sections, as shown in Figure 2. The frequency distribution (top section) lists the 21 most frequent errors by the intended function and the actual function struck. In the example, we see that the student made 26 errors when letter (LTR) was the intended function indicated by the keyboard display. He omitted the character (OC) six times, hit the "D" and the space bar (SPC) five times, hit the "E" and "N" three times, and hit the "M" and "S" two times. The top section also lists the error patterns on the last test taken.

The keyboard diagram (bottom section) shows which keys or groups are causing the most difficulty. The cumulative history provides information on mistakes the student has made consistently over a long period of testing. The last test-error display shows whether problems repeat or if new ones are appearing.

Dvorak, Merrick, Dealey, and Ford (1936) have said that a mere listing of errors has little or no meaning for the student if he does not understand the reason for these errors. However, Nathanson (1929) has speculated that a listing of persistent keystroke errors is helpful in eliminating these mistakes. While the EDRs do not specify the underlying cause of the errors (e.g., poor dexterity or lack of attention to copy), they do indicate what areas are causing difficulties. Directed practice should then help the student overcome these errors regardless of the cause. Certainly the EDRs can help the instructors discover where typing problems occur. They can then observe the student to get additional information on the underlying nature of a particular typing problem.

Because of programming, distribution, and other constraints, an EDR containing updated information for a given student is typically available no earlier than the morning following the day of a test. Since instructional material is interspersed between typing assignments, a student could not practice on the basis of immediate feedback anyway. Feedback on any one test is not likely to be of great help. It is the pattern of errors after a number of tests have been taken that leads to a clear picture of where the difficulties lie. Detailed feedback assures that students can concentrate practice on problem areas, overcome problems sooner, and complete the typing portion of the course earlier.

CUMULATIVE ERROR PATTERNS

STUDENT'S NAME: BOLIE CHRISTIN SSN: 336-58-3253

FREQ	INTENDED FUNCTION	ERROR FUNCTION	FREQ	INTENDED FUNCTION	ERROR FUNCTION	FREQ	INTENDED FUNCTION	ERROR FUNCTION
8	SPC	OC	7	O	O	7	IC	SPC
6	LTR	OC	5	P	O	5	LTR	SPC
5	LTR	D	4	CR	OC	3	IC	LTR
3	N	M	3	LTR	N	3	LTR	E
2	CR	LTR	2	A	OC	2	LTR	M
2	1	E	2	S	O	2	Y	T
2	O	R	2	R	O	2	LTR	S

ERROR PATTERNS ON LAST TEST

DATE: 09/11/79 FUNCTIONS: 681 ERRORS: 6

FREQ	INTENDED FUNCTION	ERROR FUNCTION	FREQ	INTENDED FUNCTION	ERROR FUNCTION	FREQ	INTENDED FUNCTION	ERROR FUNCTION
2	IC	CR	1	R	T	1	S	A
1	5	D	1	N	D			

CUMULATIVE ERROR DISTRIBUTION
NUMBER OF TEST TRIES: 21

KEY	1	2	3	4	5	6	7	8	9	0
FREQ										7

KEY	Q	W	E	R	T	Y	U	I	O	P
FREQ	1		4	4	5	2		5	5	7

KEY	-	BEL	$	!	&	#	'	(	)
FREQ									

KEY	A	S	D	F	G	H	J	K	L	CR
FREQ	4	5				1			2	6

KEY	"	/	:	;	?	,	.
FREQ							

KEY	FIGS	Z	X	C	V	B	N	M	LTRS	LF	SPC
FREQ	4	2	1	2	3	1	7	2	32	1	10

LAST TEST ERROR DISTRIBUTION
LAST TEST NUMBER: 41901

KEY	1	2	3	4	5	6	7	8	9	0
FREQ										

KEY	Q	W	E	R	T	Y	U	I	O	P
FREQ				1						

KEY	-	BEL	$	!	&	#	'	(	)
FREQ									

KEY	A	S	D	F	G	H	J	K	L	CR
FREQ		2								

KEY	"	/	:	;	?	,	.
FREQ							

KEY	FIGS	Z	X	C	V	B	N	M	LTRS	LF	SPC
FREQ							1				

LEGEND: BEL = BELL KEY EP = EXCLAMATION POINT CR = CARRIAGE RETURN FIG = FIGURES KEY QM = QUESTION MARK
LTR = LETTERS KEY LF = LINE FEED SPC = SPACE OC = OMITTED CHARACTER IC = INSERTED CHARACTER

Figure 2. Error distribution report.

There are a number of questions related to the implementation of APT. How often should the student receive feedback? Are there more efficient ways to use the information obtained from the automated testing? Could more efficient TTY practices and remediation techniques decrease training time? How should the automated testing and feedback be integrated into the central CMI system functioning? What are the most effective ways the school can use detailed feedback? Even if APT does not reduce test-taking time, could a reduction in overall training time be great enough to justify longer test taking time? These questions apply not only to TTY operations in the RM school, but also to training on other keyboard devices for other ratings with similar training requirements (e.g., Communications Technicians, Data Specialists, Yeomen, and Personnelmen).

Previous research in the area of APT is somewhat limited. Although many studies have been conducted to determine the most efficient methods of teaching typing (Dierks, 1977; Dixon, 1976; Krag & Van Brunt, 1970; Pask, 1960; Peterson & Staples, 1969; Rainey, 1977; Sharkey & Thomas, 1973; Sherrill, 1976; Showel, 1974; Wolcott, 1976), none could be found that dealt directly with presenting student error histories. The studies focused on the use of audiovisual presentation, group and individual pacing devices, and instructional techniques. The practice material was geared to the number of errors, not to the specific types of errors made.

Objectives

The objectives of this effort were:

1. To determine whether test-related activities take less time under APT than under manual testing conditions.

2. To determine whether training time can be reduced by different applications of EDR use, and, if so, the most feasible and effective techniques for distributing EDRs to students and instructors.

METHOD

To determine the effects of APT and EDRs on training, two experiments were conducted. These experiments are described below.

Experiment I

In the first experiment, the times required for various test-related activities under the manual and automated systems were compared to determine the absolute difference in testing times between manual and automated testing of TTY skills within a CMI environment.

Subjects

The subjects were students enrolled in the RM "A" school during 10 sessions in April 1978, when manual testing procedures were used, and during 10 sessions in August 1978, when automated testing procedures were used. Manual testing involved 4 to 12 subjects per session, depending on the number of students ready to take a test during a given session. Automated testing involved only one student per session, since such testing is individualized.

Procedure

During the experiment, records were made of the time required to complete test-related activities, including (1) filling out administrative forms, (2) announcing the test (instructor), (3) actual testing, (4) self-grading, (5) instructor grading, (6) completing administrative forms (instructor), (7) feeding the forms through the optical mark reader (students), and (8) obtaining the next assignment. The timing of similar events was recorded for students in the APT group.

Experiment II

In the second experiment, groups of students were given EDRs under different conditions to determine (1) whether EDRs could reduce the time they needed to reach the criterion level in TTY training, and (2) if so, the most efficient techniques for employing EDR feedback. It was predicted that the more frequent the updated reports, the more efficient remediation and practice would be, and the shorter the TTY training time.

Although the main dependent measures in this experiment were performance related, another measure studied was the student's attitude toward the CMI system, APT, and the EDRs. It was hoped that students would react favorably to fair and accurate testing and would appreciate receiving current and accurate information about their typing errors.

Subjects

The subjects for this experiment were 60 students in the RM "A" School. Students were randomly assigned to one of three groups as they first entered the testing room:

1. Students in the Daily (D) Group were to receive EDR feedback on the day after a test was given.

2. Students in the Remedial (R) Group were to receive EDR feedback only during their second remedial session.

3. Students in the Never (N) Group were to receive no feedback via EDRs.

Materials and Apparatus

The experiment took place in a large room with 86 TT-47 teletypewriters. An optical scanner (OpScan 17) for manual input to the CMI system was in the center of the room beside a General Electric Terminet 1200 that printed out student assignments from the main CMI computer. The 30 TTY machines in the front of the room were connected on-line to a Honeywell computer for scoring purposes.

Procedure

Due to the constraints of the computer system, the EDRs for tests taken each day could not be processed until after midnight, and thus were not available until mid-morning of the following day. For students in Group D, EDRs were generated automatically every day. If the student had taken a test the previous day, he was given the EDR the next time he reported for typing. For those in Group R, EDRs were distributed during the second consecutive appearance for remedial study, since they could not be processed until after the first reporting. Thus, if students never reported to remedial study, or did so only once, they would not receive an EDR. Students in Group N received no EDRs.

All participating students were told that an experiment was being conducted to evaluate the computer system. The experimenter described the reports and their use to students the first time they were distributed, but from then on the students studied the EDRs by themselves. The reports were distributed until all participating students had qualified at the 700 function level.

Attrition data, plus dependent measures related to TTY performance, were available from CMI response-history records. The number of TTY sessions, the number of TTY tests taken, and the number of hours spent in the TTY sessions before achieving criterion levels of performance were recorded when the first test was taken (T1), and at each of the five qualification levels (300 to 700 functions). Additionally, in the third week after data collection began, questionnaires regarding attitudes toward CMI and APT were distributed to students in the typing room regardless of whether or not they had participated in the experiment. Ten students who had received EDRs were given a questionnaire that included questions on the EDRs. Emphasis was placed on the fact that all questionnaires were anonymous. Students filled out the questionnaire on their own time. The questions included in the questionnaires are listed in Figure 3.

General:

1. How long have you been in school?
2. At what function level are you now qualified?

CMI:

1. What do you like about the CMI teaching method?
2. What do you dislike about the CMI teaching method?
3. How does the CMI method compare with having human teachers?
4. In what ways could the CMI course be improved?

APT:

1. Does the computer scoring of TYPING tests seem fair and accurate? Please explain.
2. Do you get your next assignment quickly after a TYPING test?
3. Do you understand how the computer scores TYPING tests? Please explain.
4. How could the way the computer scores TYPING tests be improved?

EDR:

1. Do the typing error analysis reports made by the computer seem helpful?
2. Do you understand how to use the typing error analysis reports?
3. How could the typing error analysis reports be improved or made better?

Figure 3. Questions included in CMI/APT attitude survey.

RESULTS

Experiment I

Table 1 provides the mean times required for test-related activities under manual testing conditions--which always involves three tests--and under automated testing conditions--which may involve one, two, or three tests. As shown, students required 2 minutes to enter course information manually on an administrative form. They also required 2 minutes to enter course information on the TTY terminal--but only when just one test was involved. If a student needed to take a second or third test, the time required increased to 4 and 6 minutes respectively (the mean number of tests taken by students under APT was 2.8).

Table 1

Time Required (Minutes) for Test-related Activities
Under Manual and Automated TTY Test Conditions

Activity	TTY Test Condition[a]			
	Manual	Automated		
	(3 tests)	(1 test)	(2 tests)	(3 tests)
Completing Course Information	2	2	4	6
Taking Tests	20	5	10	15
Waiting for Scores:[b]				
1 student	1	1	2	3
(15 students)	(8)	(1)	(2)	(3)
(30 students)	(15)	(1)	(2)	(3)
Waiting for Next Assignment[c]	3	0	0	0
Total-- 1 student	26	8	16	24
15 students	33	8	16	24
30 students	40	8	16	24

[a]Under the manual testing condition, three tests were always given. Under the automated condition, if the student passed the first test, no more tests were given. The mean number of tests taken by students under APT was 2.8.

[b]Under the manual condition, students had to wait in line for their score about one half minute each; thus, the larger the number of students, the longer the time required to wait in line. Under APT, students received their scores automatically; thus, it made no difference how many students were involved.

[c]Under APT, students received their next assignment at the same time they received their grades. Thus, no extra time was required for this activity.

There was a significant difference in the amount of time required for manual and automated testing. As shown, students in the manual group required 20 minutes, which includes the time spent getting test booklets, marking the total functions between tests, and taking the tests themselves. In the APT group, a test took exactly 5 minutes.

If the student passed the first test, this was the total testing time. However, if he needed to take a second or third test, the times increased to 10 and 15 minutes respectively, which are still 10 and 5 minutes less than the time required for manual testing.

The next activity, waiting for scores, yields the largest difference between groups. Actual scoring for the APT group was virtually instantaneous, no matter how many students were involved, but it took 1 minute to receive the printout and retrieve the next assignment. For the manual test group, the time varied with the number of students being tested. Generally, as the number of students increased, the average time required to complete scoring a student's tests increased. The actual scoring time was about .5 minute per student when 10 or more students were tested at one session.

Finally, no extra time was required to provide the next assignment to APT students. By the time the student TTY terminal finished printing the test results, the CMI Learning Center terminet had printed the next assignment. The manual test students, however, had to wait for the instructor to code their administrative forms, for a chance to feed their forms to the optical scanner, and then to receive the next assignment.

The minimum time for manual test students to complete all activities (assuming 1 student) was 26 minutes; for APT students, the minimum time (assuming 1 test) was 8 minutes. Even when all three tests were taken by APT students, the mean time required was 24 minutes. This is still less than the 26 minutes a manual test student requires to complete the testing cycle (even if scoring were immediate), and much less than the 40 minutes required when 30 tests must be scored.

Experiment II

Similarity of Subject Groups

As a check on group equality, group mean Armed Services Vocational Aptitude Battery (ASVAB) qualifying scores were compared, and no significant differences were found. Prior typing experience could also influence TTY progress, since students with typing skills usually do not need the full eight practice sessions to pass the first test for 300 functions. Thus, to check on the equality of groups with respect to typing experience, the mean numbers of TTY sessions up to and including the first test were compared. The mean numbers of hours spent in basic typing instruction prior to the first test were 16.8, 15.3, and 17.7 for D, R, and N groups, respectively. These differences were not significant, again indicating similarity of the subject groups.

Attrition

Fifteen of the 60 subjects were dropped, for an overall attrition rate of 25 percent. This included three (15%) from Group D, five (25%) from Group R, and seven (35%) from Group N (see Table 2). Although some students were dropped for academic reasons, and others, for motivational or disciplinary reasons, persons in both attrition categories were having difficulty in the typing portion of the course. In fact, according to the Service School Command in San Diego, 12 of the 15 attrites (80%) were having problems with typing when they were dropped.[2] This included two (10%) from Group D, and five (25%) from Groups R and N. Attrites spent an average of 58.6 days in the course.

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[2]Chief of Naval Technical Training RM "A" Attrition Message 052220Z December 1978.

Table 2

Performance Data for Students in EDR Groups

Group	TTY Qualification Level: T1[a]	300	400	500	600	700
			Attrition			
D (Daily)	20	20	20	20	20	17
R (Remedial)	19	19	19	18	17	15
N (Never)	19	19	19	18	14	13
			Mean Number of Hours to TTY Criterion[b]			
Actual Ns:						
D	17	24	32	43	67	80
R	15	25	34	51	66	74
N	18	27	44	57	68	84
Adjusted Ns:[c]						
D	17	24	32	38	49	64
R	15	25	34	51	56	65
N	18	28	44	57	68	84*
			Mean Number of TTY Sessions to Criterion[d]			
D	7.5	9.9	12.6	15.6	23.2	25.7
	(2.6)	(4.0)	(5.2)	(4.9)	(8.0)	(7.4)
R	7.4	11.6	14.0	16.0	23.1	24.4
	(2.6)	(5.2)	(5.4)	(4.7)	(9.6)	(7.0)
N	8.2	11.7	16.1	18.1	22.5	26.0
	(2.0)	(3.8)	(5.0)	(3.6)	(7.1)	(6.0)
			Mean Number of TTY Tests to Criterion[d]			
D	--	5.0	9.1	15.8	25.2	32.0
	--	(3.1)	(7.0)	(12.6)	(17.0)	(21.8)
R	--	9.2	14.9	24.2	33.1	39.6
	--	(7.1)	(11.6)	(16.1)	(21.1)	(24.8)
N	--	7.8	15.9	26.8	29.7	40.4
	--	(6.6)	(13.8)	(18.0)	(20.9)	(22.7)

[a]Point at which first test was taken.

[b]Hours were rounded to the nearest whole hour.

[c]At the 500, 600, and 700 levels, the numbers of students in each group were equalized to test for contamination of data.

[d]Nos. in parentheses are standard deviations.

Number of Hours in TTY Sessions to Criteria

Table 2, which includes the mean numbers of hours students spent in TTY sessions before reaching the various qualification levels, shows that the difference between Groups D and N increased up to the 500 level. However, at the 600-function level, data from all three groups converged, primarily because of the increase in time required for Groups D and R to reach that level, rather than from a change in the rate of Group N. While the groups separate again at the 700 level, the differences are not large.

The cause for the convergence at the 600 level may be related to the differential attrition rates among the groups, which may have contaminated the data. Since most of the attrites were dropped for taking an excessive amount of time to reach the 500, 600, or 700 levels, it may be that the groups with lower attrition rates--D and R--had a higher proportion of poor students at those levels. The EDRs may have helped the marginal students in Group D, and, to a lesser extent, those in Group R, at least enough to finish the course. If those marginal students had been dropped, the mean time for Groups D and R may have been substantially lower.

To investigate this possibility, the numbers of students in each group at the 500, 600, and 700 function level were equalized. Since Group N had the lowest number, the other groups were reduced to that number. In this process, data for the slowest students from Group D and R were deleted since it was assumed that these students would be most similar to the students who dropped out from Group N. The resulting data are presented in Table 2, which shows that it took the students in Group N a significantly longer time to reach the 700 level than it did those in Groups D and R ($t\ (37) = 1.94$, $p < .05$).

Number of TTY Sessions to Criteria

Results of an analysis of variance on the mean numbers of TTY sessions required by group members to reach criterion revealed no significant differences between groups, when using either actual or adjusted data. The TTY session data shown in Table 2, however, may display a ceiling effect. At the RM school, students are allowed only 21 sessions to reach the 500 level; and 33 sessions, to reach the 700 level. Records showed that one third of the students required 21 sessions to reach the 500 level. Of those, all but two either required 33 sessions to reach the 700 level or failed to reach it and were dropped from the course. Therefore, without the limit on the number of sessions at the 500 and 700 levels, some students would have spent many more sessions trying to qualify at these levels.

Number of TTY Tests to Criteria

Data on the mean numbers of TTY tests taken (Table 2) indicate the same trend in results as the previous measure; these were no significant differences among the means. Again, this picture was not changed by adjusting the data for attrition. This might have been expected, since there were large differences in individual testing strategies. Some students wanted to take tests often, while others tested only when required.

Attitude Survey

Seventy-six attitude surveys were returned, including eight of the ten with questions on EDR. Table 3, which provides responses by student qualification level, shows that, although students were generally positive toward both CMI and APT, they were more positive toward the APT portion of CMI than to the system in general. Attitudes seemed to be strongly affected by what qualification level the respondents were trying to achieve

Table 3

Responses to CMI/APT Attitude Surveys

	Respondents at TTY Qualification Level				
Survey Topic	300 (%)	400 (%)	500 (%)	600 (%)	700 (%)
CMI (N = 76):					
Positive	57	68	43	51	37
Negative	43	32	57	49	63
APT (N = 76):					
Positive	57	73	54	74	41
Negative	43	27	46	26	59
EDR (N = 8):					
Positive	100	100	100	100	100
Negative	0	0	0	0	0

at the time of responding. Attitudes did decline at the 500 and 700 levels. When students were attempting to reach 700 level, their attitude was clearly negative. All eight students who returned surveys with EDR questions indicated that they were satisfied with the reports.

DISCUSSION AND CONCLUSIONS

The experiments show that APT with proper feedback aids in teaching TTY skills. The APT testing time was shorter than manual testing time, as shown by the first experiment, and frequent distribution of the EDRs was beneficial. Students receiving feedback not only finished the typing portion of the course faster than other students, but attrition from typing problems was lower.

One reason why APT speeded testing was that students under APT did not need to take all three tests if they passed one of the first two. Also, they had the opportunity to practice between individual tests if their performance on the first or second test indicated extra practice was needed. Students could take tests when they felt they were ready, not just whenever the test was given, while the manual group was arbitrarily required to take all three tests. An additional advantage for the APT students was the option to terminate a test if they realized they had already made too many errors before the 5-minute period was over. APT gave students more time to practice and improve their typing skills. It also allowed the instructor to spend more time helping students with typing problems instead of performing administrative scoring duties.

The morale factor is also important. APT eliminates the irritation students feel at delays for test grading, and the tedious responsibility instructors face in grading tests. Because instructors are free of irksome tasks, they may feel better about their job and can teach more effectively.

Probably the most important by-product of APT is the ability to provide detailed feedback concerning typing errors to both students and instructors. Although EDRs were not available until the day after a test was taken, students were usually given nontyping assignments after TTY tests and immediate feedback could not be used anyway. EDRs were usually available by the time the student got his next TTY assignment. Most students receiving EDRs took advantage of the feedback by studying them carefully and concentrating practice on the areas of greatest error. This concentration on specific areas would seem to be the reason for the improved performance of the EDR groups over groups not receiving EDRs. The performance differences in the time required to reach the 700-function level were significant and nearly all the other comparisons were consistent. The evidence is less clear when the number of sessions is considered, but this inconsistency seems to be a ceiling effect due to the restriction in the number of sessions students were permitted.

General approval of the APT and EDR programs by the students was an added benefit. The survey data showed that more students responded favorably to APT than to the CMI system itself, indicating that they considered APT improved the course. This attitude was pronounced, although it was clear that some students did not understand computer operation, challenged the accuracy of computerized scoring, and even. in some cases, insisted it was inaccurate. These misunderstandings indicate that the test scoring process must be explained and that, if students were better informed on computer operations, their attitudes would improve and the acquisition of knowledge and skills would be faster and better.

The survey responses showed a favorable reaction to the EDRs. All students completing the survey said the reports were worthwhile, and a large number of students not in the experiment requested reports on a regular basis. Many students were eager to see their next report and studied them carefully. They were pleased to receive useful information from the computer. It was clear that the feedback lessened the boredom of typing practice, increased motivation, and heightened interest in acquiring skill.

It is possible that, without EDRs, some students with severe typing problems might have become frustrated with the course, developed severe TTY problems, and dropped out of the course. Conversely, when the EDRs were available, they may have given some students needed encouragement through the feedback that showed their progress in overcoming errors. The attrition data supports this assumption--the attrition rates for Groups D, R, and N were 15, 25, and 35 percent respectively. The D group had no dropouts for motivational or disciplinary reasons.

Use of the EDRs to guide practice may have helped marginal students to stay in the course until completion. The benefit of saving these students has an associated cost; they need more time to complete the course. In fact, the performance times of the marginal students who would have dropped out without the EDRs probably accounted for the relatively high mean performance times for the EDR groups beyond the 400-function level. The marginal students undoubtedly accounted for the 20 percent differential attrition between groups D and N. After adjusting the data for differential attrition, it is clear that the EDR groups were superior to the N group, taking much less time to reach the 700-function level.

To understand the importance of the time saved, the associated cost avoidance must be examined. The savings in time to reach the highest required level of performance (700-functions) between groups D and N was 19.8 hours, or just under three 7-hour CMI training days, based on the data adjusted for differential attrition. With the marginal students included, however, the difference was minimal. Since the large difference was

computed with only 13 of the 20 students, the actual savings apply only to those 65 percent of the students who were not marginal. The cost per student enrolled per day in the RM "A" school, according to the specialized training costs group under the Chief of Naval Education and Training, was projected to be $83.92 in 1979, including military and civilian pay, machine maintenance, and general overhead. Data in this present report are based on a small experimental sample of students. However, if the results were extended over the projected 1979 enrollment of 3106 students (RM school figure), the cost saving would amount to $479,000 ($83.92 per student day x 2.83 days x 3106 students x .65). The potential for additional Navy-wide savings could be exploited if APT techniques were developed and implemented in other schools that have similar typing requirements.

Based on the preliminary results of this effort, procedures for the optimal use of EDRs were developed through the coordinated efforts of the RM school, IPDC, and NAVPERSRANDCEN. These procedures included guidelines for distribution of the reports and use during classroom remediation. Specifically, under these procedures, instructors receive reports on students who fail to qualify at a required level of performance. The students are also given a copy of the EDR and suggestions on what to practice. According to these guidelines, students are given the report and counseling even if they never report to night study. This is almost equivalent to providing the student with "daily" reports, since "daily" operationally refers to any time a test is taken. The student gets little help from feedback on a test that is "passed," since so few errors are made. Therefore, giving students reports after "failed" tests provides them with nearly as much information as giving reports after every test.

At the completion of these experiments, the RM school was following these guidelines and the instructors were satisfied with them. The programs developed in this effort represent a significant advancement in instructional technology used in automated performance testing. The APT technology has demonstrated the potential to effect substantial savings in the RM school through reduced training time and less attrition, and could now be applied to performance skills involved in other CMI courses.

RECOMMENDATIONS

1. The RM school should continue to use APT and EDRs.

2. The Chief of Naval Technical Training and the Service School Commands should exploit the potential cost-effectiveness of APT at other Navy technical training schools.

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